TARDEC

— TECHNICAL REPORT —

THE NATION'S LABORATORY FOR ADVANCED AUTOMOTIVE TECHNOLOGY

No. 13840

Evaluation of Purging Solutions for Military Fuel Tanks

May, 2003

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WINNER OF THE 1995 PRESIDENTIAL AWARD FOR QUALITY

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13. ABSTRACT (Maximum 200 words) Citrikleen is a terpene based solvent and its component is derived from d-limonene or pine tree. It is also a biodegradable water based solvent. Because of this property, US Army has used this environmentally friendly solvent as a purging solution in all military fuel tanks including Heavy Expanded Mobility Truck (HEMTT) for the last eight years. Recently, TACOM Logistic Assistance Representative (LAR) reported that Citrikleen solvent damages rubber seal equipped in Tank and Pump Units (TPUs), HEMTTs, and 5000 gallons of fuel delivery trucks. To clarify this problem, a seal compatibility test was conducted with Citrikleen solvents according to the ASTM D 471 test method for Rubber Property-Effect of Liquids. To draw a baseline for this evaluation, two fuel samples (i.e., JP-8 and DF-2) were tested along with Citrikleen. In addition, three more solvent were also tested to make a comparison against Citrikleen solvent. Based on the seal compatibility test results, this paper summarizes test results and findings, and re-defines Citrikleen solvent as a purging solution for military fuel tanks.

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1. BACKGROUND

Citrikleen is a terpene based solvent and its active component is derived from d-limonene or pine tree. It is originally formulated with a multi-component emulsified surfactant system, and is known as an environmentally compliant biodegradable solvent. Citrikleen solvent was specially designed so that fuel/water/solvent mixture will separate (fuel and solvent/water) when using an oil/water separator. The U.S. Army Tank-Automotive Armament Command (TACOM) has approved Citrikleen as a purging solution because of its environmentally acceptable properties. For a decade, the military has successfully used this solvent for cleaning all military fuel tanks including Heavy Expanded Mobility Tactical Truck (HEMTT) Tanker shown in Appendix A. The purging procedure associated with Citrikleen has been developed and described in a General Precautionary Message (GMD), TACOM No. 94-02 that is included as Appendix C. This purging procedure is summarized as follow:

(1) Drain all petroleum product from fuel compartments, piping, manifolds, meters, retails hoses and filter separators.
(2) Fill all fuel compartments half way (50 %) with water. Then, add 6 gallons of Citrikleen for 2500 gallons of water or 0.24 % concentration of Citrikleen. After that, fill the tank to full capacity water.
(3) Operate the vehicle for approximately 5 miles to agitate the solution throughout the tanker.
(4) Drain all contaminated water using an oil-water separator at authorized hazardous waste disposal site.
(5) Rinse fuel compartment with clean water over the oil-water separator.
(6) Dry the fuel compartment using a compressed air for approximately 2 hours.
(7) Inspect fuel residue until zero reading using an explosive meter.

Recently, TACOM Logistic Assistance Representative (LAR) of Ft. Bragg reported that Citrikleen solvent might have adversely affected rubber seals equipped in Tank and Pump Units (TPUs), HEMTTs, and 5000 gallon fuel tank trailers. In addition, there was a concern that Citrikleen might kill microorganism, used in waste water treatment center. To clarify these issues, the TACOM LAR requested assistance in determining whether Citrikleen solvent actually damages seal materials used in military fuel tank systems and whether its use affects waste treatment procedure. These issues were not reported before and no data was available for evaluation. Therefore, an investigation was initiated to determine if Citrikleen solvent might damage seals and upset waste water treatment processes. This paper describes the test results from seal compatibility test and bacteria survivability test, findings, and recommendations.

2, TEST SAMPLES

A total of eight samples were selected for this investigation. To draw a baseline for this study, two fuel samples (i.e., JP-8 and DF-2) were selected along with Citrikleen. In addition, three more solvents were selected to compare against two Citrikleen solvents (i.e., d-limonene and pine oil base). One was MIL-PRF-680[1]Type IV hydrocarbon solvent that contains d-limonene material, while the other one was a d-limonene based cleaner similar to Citrikleen. The last one was Starpower cleaner supplied by TACOM LAR of Ft. Bragg. The plain water was also selected to draw an additional baseline of this study. These samples are described in following Table 1.

Table 1. Test Samples

Code	Sample	Chemical Composition
S-1	Citrikleen (A)	D-limonene, Surfactant, others
S-2	Citrikleen (B)	Pine, Surfactant, others
S-3	JP-8 Fuel	Hydrocarbon
S-4	DF-2 Fuel	Hydrocarbon
S-5	MIL-PRF-680 Type IV	D-limonene, Hydrocarbon
S-6	Rip-Tide RI	D-limonene, Surfactant, others
S-7	Starpower	Proprietary chemicals, Ethylene Glycol Monobutyl Ether, others
S-8	Water	H_2O

3. SEAL COMPATIBILITY TEST

A gasket is commonly used to seal a passageway preventing an unwanted escape or loss of fluid. Many different types of gasket materials (i.e., rubber, metal, paper, etc.) are currently using in the mechanical systems. The seal material utilized in military fuel tanks is Rubber Butadiene Acrylonitrile and is quite common for fuel systems. This nitrile rubber is known for resistance to oils and solvents. Because of this property, most military rubber specifications requiring fuel and oil resistance require nitrile base seals. Figure 1 shows O-rings currently used in military fuel tanks and identified by the LAR as being affected by Citrikleen. These O-rings are made by nitrile elastomers.

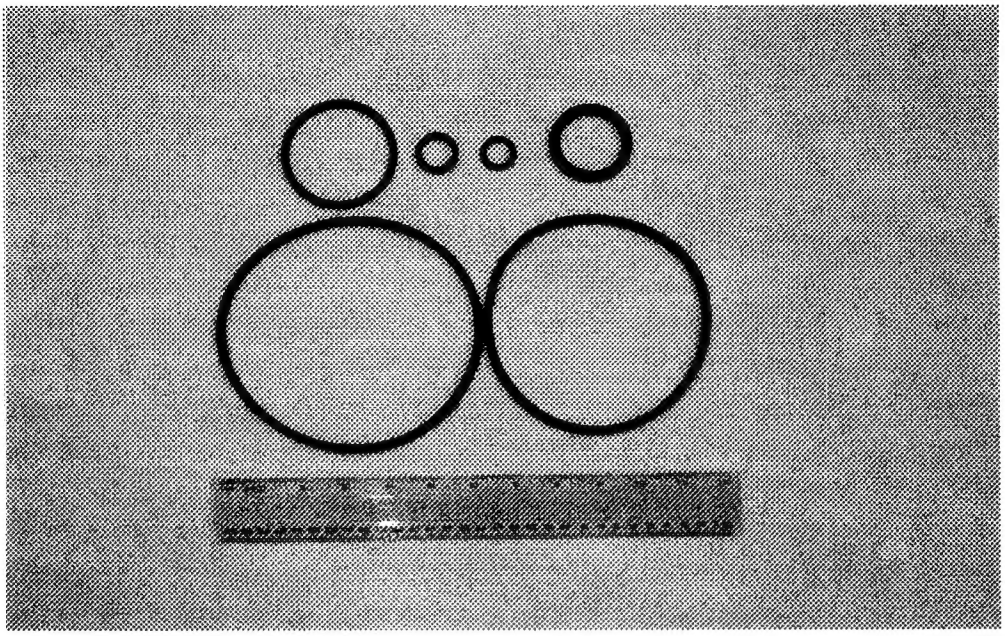


Figure 1. O-rings used in Fuel Tank

With these O-rings, a seal compatibility test was conducted with Citrikleen solvent according to ASTM D 471 test method for Rubber Property- Effect of Liquids. To simulate field environment, two different test temperatures (25 °C and 50 °C) were selected for the tests. Currently, the purging is actually performed at normal ambient temperatures. The duration of this seal compatibility test was set for 72 hours. For the test, both Citrlikleen solutions (d-limonene and pine) were prepared according to TACOM purging procedure (0.24 % of Citrikleen in water). Also, the other water based samples were prepared using the military purging procedure except for fuels and hydrocarbon based solvent. Then, an O-ring was uniformly cut in small piece (about 0.5 inches in length) and immersed in the test solutions. Figure 2 shows the seal swell tests for this evaluation.

The seal compatibility test results are summarized in Table 2. Some samples were only tested at 25 °C due to their low flash points. For the evaluation, the hardness and swell changes were measured according to the ASTM D 471 test procedure. There were no hardness changes in all tested products. The test results showed that both Citrikleen solvents did not give any major seal compatibility problem with nitrile rubber. Their swell changes were very similar to the other tested products including military fuels. The test results also showed that DF-2 fuel affected the seal material more than any other samples. However, all the swell changes were within a permissible limit (10 %) specified in MIL-P-5315B specification, Packaging, Preformed, and Hydrocarbon Fuel Resistant. The concentration of Citrikleen used in the purging procedure is only 0.24 %. Such a tiny amount of Citrikleen solvent does not affect seal materials used in military fuel tanks

under normal ambient temperatures. In addition, the test results showed that any of products associated with fuel tanks (i.e., fuels, Citrikleen, water) did not have seal compatibility problem. In general, the deterioration of O-ring seals was normally found due to the seal aging or incompatibility with chemical solutions. Both cases tend to lead the leakage of O-ring seal. In this case, it appears that the seal deterioration problem observed at Ft. Bragg can be considered as an aging problem rather than Citrikleen solvent.

Table 2. Volume Changes in Seal

Test Sample	Test Temperature	
	25 °C	50 °C
Citrikleen (d-limonene)	1.0%	3.0 %
Citrikleen (pine)	3.2 %	6.5 %
JP-8 Fuel	4.3 %	NT*
DF-2 Fuel	7.1 %	NT
MIL-PRF-680 Type IV	3.7 %	NT
Rip-Tide RI	2.5 %	4.7 %
Starpower	1.7 %	2.4 %
Water	0.5 %	1.7 %

* Not tested

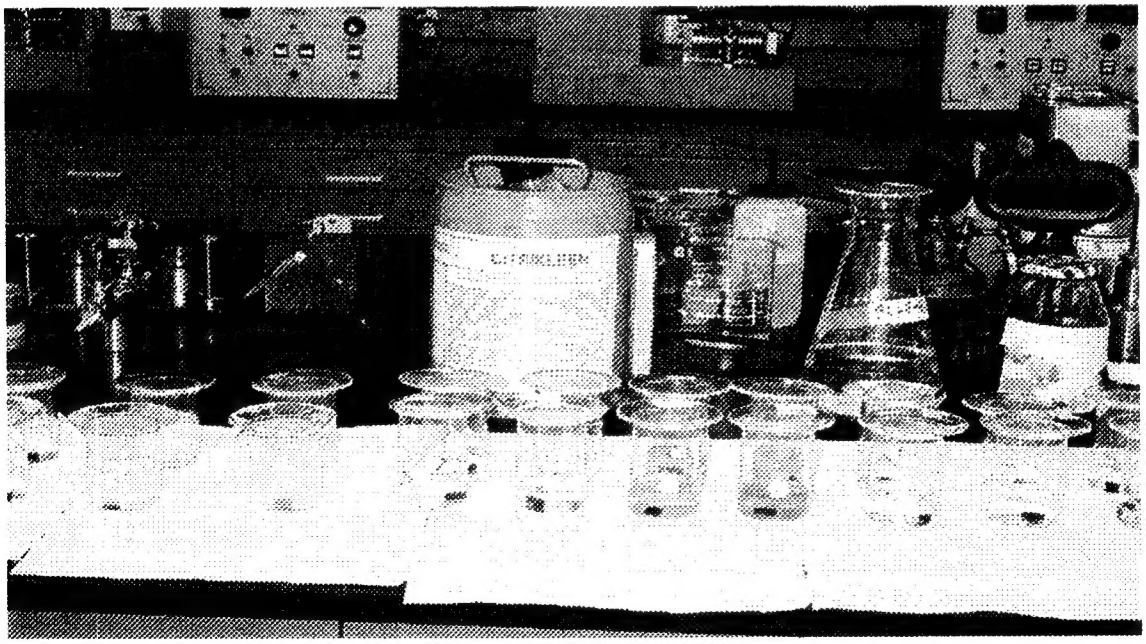


Figure 2. Seal Compatibility Test

4. MICROORGANISM SURVIVABILITY TEST

D-limonene is major component of the oil extracted from citrus rid. This natural oil is used to make many different types of products such as paint solids, orange fragrance, bug killer, and cleaners. By combining d-limonene with surfactant package, a water dilutable and rinsible solution can be made to use in the household or industrial cleaning applications. Citrikleen is one of these solutions. Recently, some military users thought that Citrikleen used in the purging procedure might harm the microorganism utilized in the domestic waste water treatment centers because d-limonene is also used to make an insecticide material to kill the bugs. But there was no documentation available to support this claim.

Wastewater treatment centers are currently using many different types of microorganisms in their biodegradation process. The microorganisms involved in biotreatment can be classified into three main groups as follow:

- Bacteria are unicellular organisms capable of living on a wide variety of organic materials. They range in metabolism from heterotrophic (living on organic carbon compounds) to lithotrophic (using inorganic compounds as sources of energy) and phototrophic (using sunlight as a source of energy). They generally reproduce by dividing into two equal daughter cells.

- Fungi are larger more complex organisms and can exist as either filamentous forms or as unicellular organisms and are larger than bacteria. They are all dependent on organic carbon as a source of energy.

- Algae are all photosynthesis organisms, which use sunlight as a source of energy and carbon dioxide from the atmosphere as a source of carbon for cell growth. These microorganisms are not used as inoculums for biodegradation processes.

The life and growth of these microorganisms often depends on the source of food chain, toxicity, and the surrounding environment. Some toxic chemicals may damage microbial cell structure and kill the microorganism. At present, the most practical way to detect this damage is to determine if microbial cell can still reproduce when exposed to a suitable environment. If the microbe is so disturbed metabolically and structurally that it is unable to multiply, then it is no longer viable. The permanent loss of reproductive capability has become the accepted microbiological definition of death.

To determine if d-limonene harm/affect microorganism used in the wastewater treatment center, a microorganism survivability test was conducted using two d-limonene based cleaners (i.e., Citrikeen, Rip-Tide RI). In addition, Starpower cleaner (code S-7) was tested to make a comparison between d-limonene based cleaner and none d-limonene based cleaners. An activated sludge sample from a local wastewater treatment center, shown in Figure 3, was also tested as a baseline of this study.

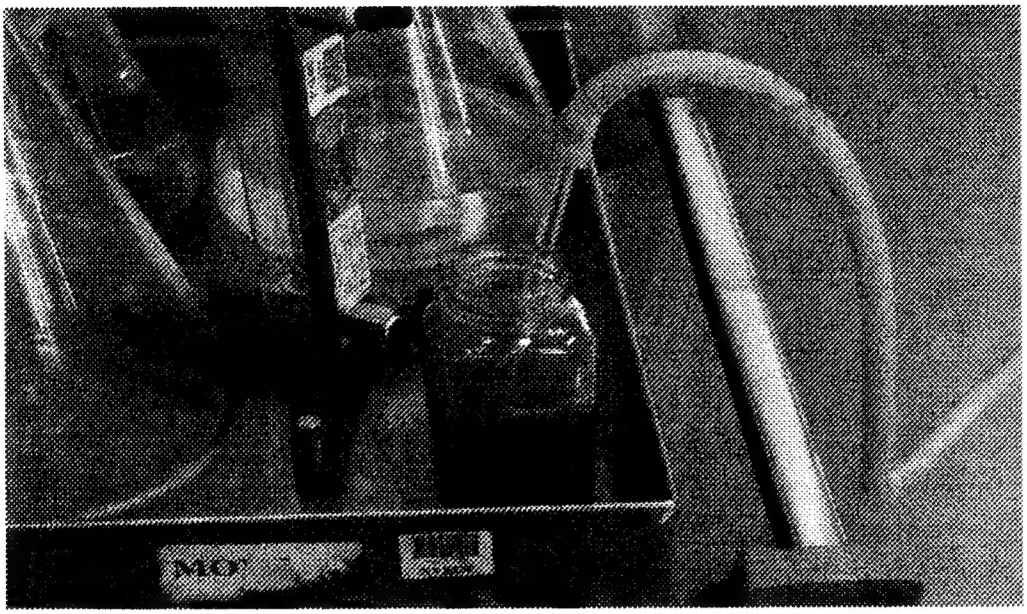


Figure 3. Activated Sludge from Wastewater Treatment Center

Figure 4. Sample Preparation for Microorganism Survivability Test

For the test, the 100 ml of test samples were prepared according to the TACOM purging procedure and the 20 ml of activated sludge was added in each test sample. This microorganism survivability test is shown in Figure 4. Then, each samples were cultured using the Easicult Bacteria Counting kit[2]. This test kit is commonly used for measuring the growth of bacteria in industrial process, such as cutting fluids, etc. This cultured test kit was stored in an incubator at 27 °C. After three days incubation, the bacteria were counted in compared to Total Bacteria Count Agar (TTC) Chart that was supplied with the test kit. This chart is shown in Appendix B. As a plan, the tests were conducted for three days to verify the test objective.

The microorganism growths in the test kits are illustrated in Figure 5 and the test results are shown in Figure 6. In these tests, the bacteria were counted at the beginning, one day, and third day. Both d-limonene cleaners (Citrikleen, Rip-Tide RI) tend to support bacteria reproduction from $1x10^4$ to 1×10^5 cells, while non-d-limonene based cleaner (Starpower) decrease bacteria from $1x10^4$ to $1x\ 10^3$ cells. The numbers of bacteria from water treatment were not changed for three days. It was also observed that Fungi slightly grew in all tested samples. These test results clearly demonstrate that the amount of Citrikleen specified in purging procedure does not harm the microorganism from water treatment center. It also showed that Rip-Tide RI cleaner tends to increase the reproducibility of microorganism. In the previous study, the biodegradability of Citrikeen was found 86.5 % in EPA 796.3100, Aerobic Aquatic Biodegradation Test.

It is reasonable to assume that Citrikleen will undergo rapid and ultimate biodegradation in aerobic aquatic environments. Both test results gave a good agreement. It appears that Citrikleen become a bacteria's food rather than harms to bacteria. Therefore, there was no evidence to support Citrikleen or d-limonene based cleaners kill microorganism from the wastewater treatment center.

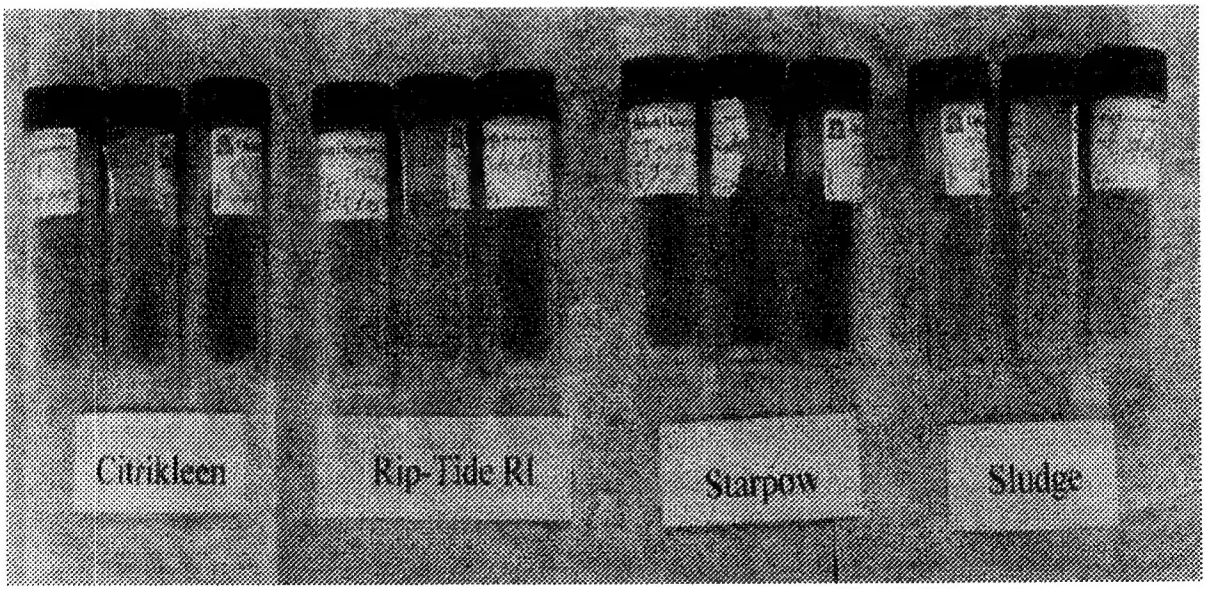


Figure 5. Microorganism Survivability Test

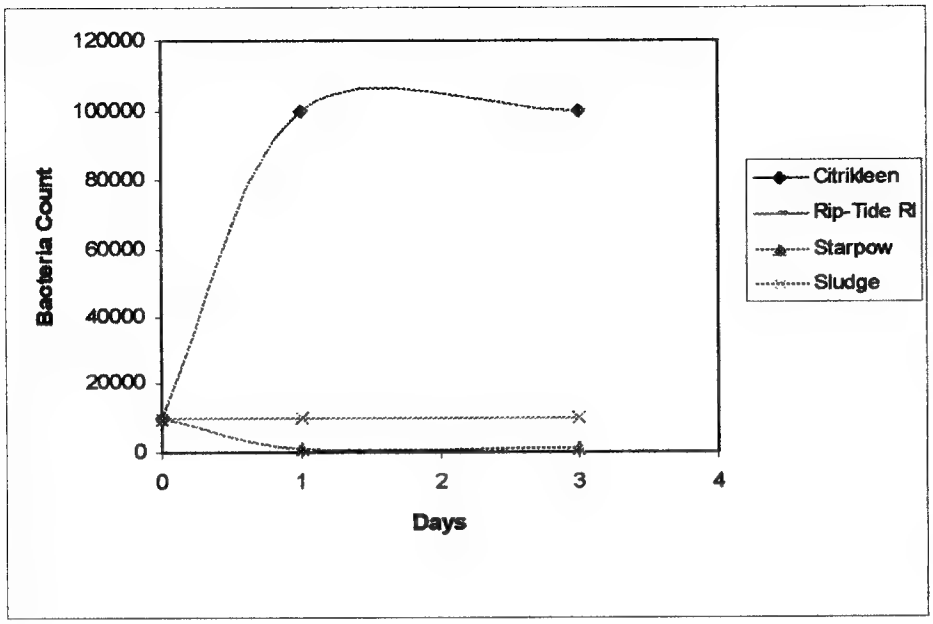


Figure 6. Microorganism Growth

5. CONCLUSIONS AND RECOMMENDATIONS

On the basis of the work completed to date, Citrikeen solvent does not damage seal materials used in military fuel tanks. The test results showed that the diesel fuel tended to attack seal material more than Citrikleen does, however, still within allowable tolerance. The microorganism survivability tests demonstrated that Citrikleen or d-limonene based cleaners do not harm microorganisms used in the wastewater treatment center even at the concentrations used in purging procedures. Therefore, a tiny amount of d-limonene concentration used in military purging procedure does not affect microbial life.

Based on the test results and findings, it is recommended that Citrikleen can be continuously used as a purging solution in military fuel tanks. However, a large amount of water used in the purging procedure may create environmental problem such as generation of a high volume of contaminated water. Although Citrikleen does not harm microorganisms, it must be separated from the contaminated water prior to discarding the solution to the sanitary sewer.

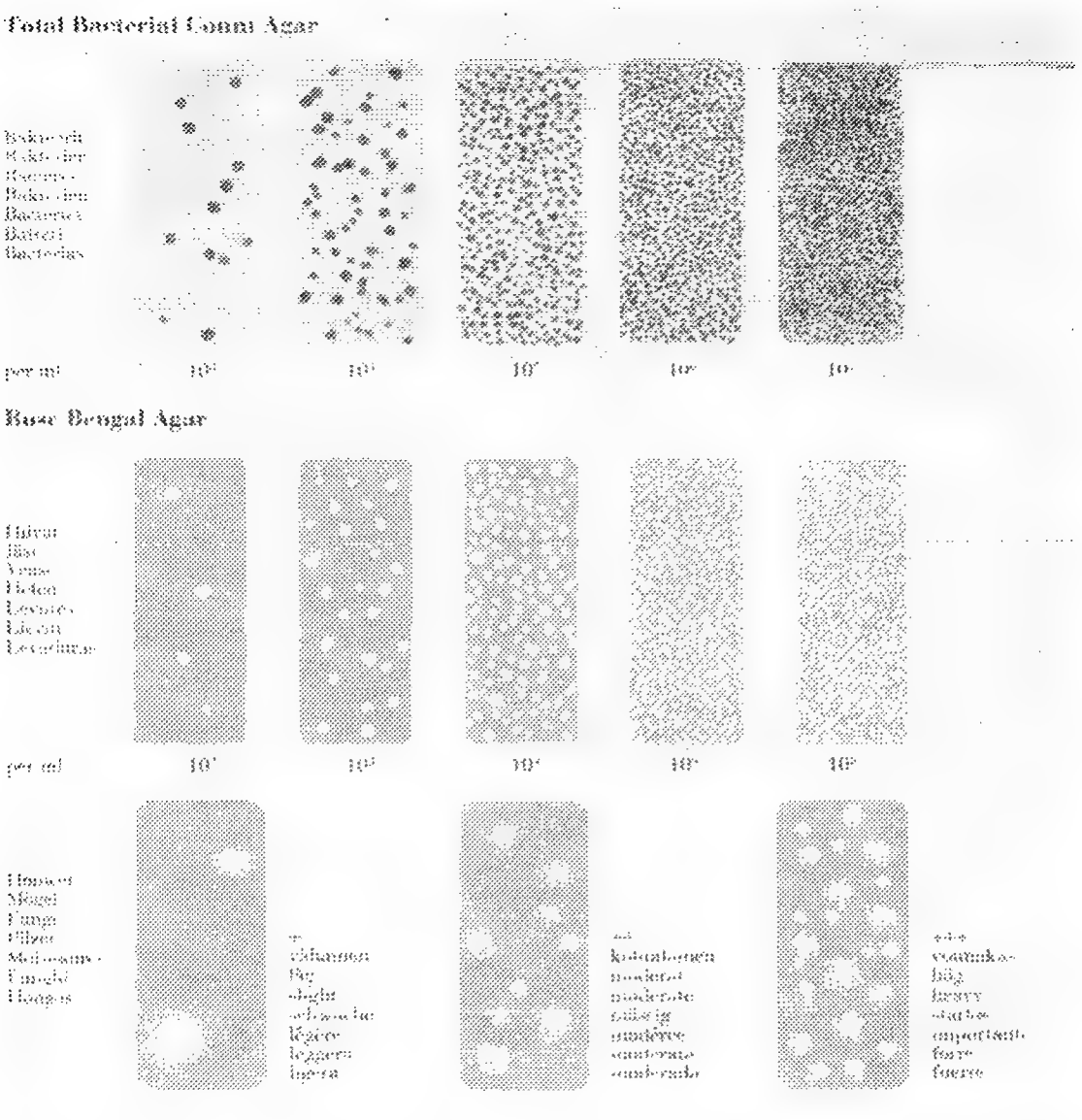
REFERENCES

1. MIL-PRF-680, Degreasing Solvent, 13 December 1999.

2, Eassicult Test Kit, Orion Diagnostica Corporation.

Appendix A. Heavy Expanded Mobility Tactical Truck (HEMTT) Tanker

Appendix B. Total Bacterial Count Agar (TTC) Chart



Appendix C. Ground Precautionary Message (GPM), TACOM No. 94-02

2-8. GPM No. 94-02

Ground Precautionary Message (GPM), TACOM No. 94-02

"Maintenance Advisory" for purging all fuel tankers using a biodegradable purging solution.

DATE/TIME GROUP	POC	ALTERNATE	ORGANIZATION
111944Z Feb 94	Mr. Walter Kellogg DSN 786-8300 Commercial (810) 574-8300	Mr. Steve Bowman DSN 786-5717 Commercial (810) 574-5717	AMSTA-MVA or
Tactical Vehicles	Mr. Jim Howard DSN 786-7515 Commercial (810) 574-7515	Ms. Karen Harris DSN 786-7910 Commercial (810) 574-7910	AMSTA-MTC or
Long Term and Prepositioned Storage	Mr. Tom Burmeister DSN 786-6142 Commercial (810) 574-6142		AMSTA-GTPL or
Quarter Master School for purging of tankers	Mr. Chris Parent DSN 539-3728 Commercial (804) 765-3728	Cpt McCaw	ATSM-CDM or
Petroleum Center for fuels	Mr. Jim Lupori Commercial (717) 770-4230/6277		Log Read/Ops Div or
Confined Space Restrictions	Mr. Ray Holland DSN 471-6838 Commercial (210) 221-6838		HSC-HSAP

2-8. GPM No. 94-02 cont.

PROBLEM:

A. There are currently no instructions published for purging fuel tankers using a biodegradable purging solution, NSN 7930-01-350-7034 or NSN 7930-01-350-7035.

B. This message provides proper guidance for use and disposal of biodegradable purging solution. Failure to follow these instructions may result in vehicle damage or loss of life.

USER ACTIONS:

A. Connect a ground cable to the fuel tanker and drain all petroleum product from fuel compartments, piping, manifolds, meters, retail hoses and filter separator.

B. Remove filter elements and go/no go fuses from filter separator.

NOTE

When purging the M970 fuel tanker with a water solution it is necessary to bypass the automatic float shutoff valve. This is accomplished (after removing your fuel water separator filters) by unscrewing the pin in the center of the automatic float and placing a 1/2 inch ID x 1 1/2 inch long piece of PCV piping over the shaft of the pin and then reinstalling the pin.

C. Remove meter screen and nozzle screen. Drain all petroleum product from filter separator's water sump and close/plug all valves and ports.

D. Fill all fuel compartments half way (50%) with water. Add biodegradable purging solution using the following chart, then continue to fill the tank to full capacity with water.

TANKER CAPACITY		GALLONS OF PURGING SOLUTION REQUIRED
7500 gallon	-use-	18 gallons of solution
5000 gallon	-use-	12 gallons of solution
2500 gallon	-use-	6 gallons of solution
1200 gallon	-use-	3 gallons of solution
525/600 gallon	-use-	1.5 gallons of solution

E. Close and secure all compartment hatch covers. Close all valves. disconnect ground cable from the tanker.

2-8. GPM No. 94-02 cont. F. Operate the vehicle for approximately 5 miles to agitate the solution throughout the tanker.

NOTE

The purging solution can be transferred into another tanker and re-used up to "three" times. The solution is biodegradable; however, oily particles remain in the mixture. Therefore, when disposing of this solution, ensure the oil water separator is properly monitored IAW local regulatory guidance.

G. If you are not going to transfer the purging solution mixture to another tanker, position your tanker over a oil water separator at authorized hazardous waste disposal site for unit or installation.

H. Ground your fuel tanker and open all inter-compartmentdl dump valves. Circulate the water and biodegradable purging solution mixture through the pump, meter, fuel separator and dispensing hoses for 3 minutes.

I. Tankers with onboard pumps, do the preceding operation with onboard pump running.

J. Open all dump valves and the gravity port. Drain water/purging solution mixture over an oil water separator.

K. After all the water/purging solution mixture has been drained, rinse fuel compartments with clean water over the oil-water separator.

L. Using an explosivemeter, take a vapor reading from each fuel compartment. A vapor reading of .0 should be obtained. If the vapor reading is more than .0, open all valves on petroleum tank, including the drain valve and filter separator. Completely unroll fuel dispensing hoses and tie nozzles open. Air-dry the fuel compartments for approximately 2 hours. Continue to take vapor readings every hour thereafter until a reading of .0 is obtained.

M. When purging is complete, close all valves/ports, and replace all filters IAW the appropriate vehicle's TM.

NOTE

Before installing your filters in your M970 fuel tanker, remove the piece of PCV piping installed on the float pin. Discard the PCV piping and reinstall the pin.

2-8. GPM No. 94-02 cont.

N. To expedite the purging of your fuel tankers (approximately 20 minutes drying time), you may obtain an air dry system NSN 4140-01-306-9138 (managed by SSG) at a cost of $2,244.91 ea, and utilize the following procedure:

1. Position petroleum fuel tank vehicle in open area away from any buildings or spark producing equipment. Ground petroleum tank vehicle. Make sure there is nothing in the immediate area that will ignite vapors being released from petroleum fuel tanker.

2. Open all valves on petroleum tank vehicle, including drain valve on filter separator.

3. Completely unroll fuel dispensing hoses and tie nozzles open.

4. Place electric (explosion-proof) blower and 8" x 15' conductive ducting close enough to petroleum fuel tanker so that the conductive ducting can reach all hatch covers .

5. Ground electric blower using grounding cable assembly.

6. Place cell duct adapter plate over fuel compartment hatch cover and ensure a tight seal is obtained. Use tape if necessary to seal compartment completely.

7. Turn on air blower and force air into fuel compartments. Check fuel compartments for petroleum fuel vapors every hour with an explosivemeter. When the explosive meter's combustible level reads .0, the fuel compartments are vapor free.

O. When purging is complete, close all valves/ports, and replace all filters IAW the appropriate vehicle's TM.

ADDITIONAL SAFETY INFORMATION:

A. A fuel tank is considered a confined space. You "must" comply with all applicable sections of OSHA's permit-required confined space standard, 29 CFR 1910.146, and any installation regulations before entering a fuel tank. Commanders, ensure all persons performing this operation are completely trained and knowledgeable of these requirements.

B. Installation safety personnel must inspect the job site to determine safety requirements and the necessary Protective Clothing and Equipment (PCE). PCE must be fitted and validated by medical personnel.

2-8. GPM No. 94-02 cont.

C. Each person must be tested and approved by installation medical personnel before entering a fuel tank.

D. 2 people are required when inspecting or repairing a fuel tank. 1 person must remain outside the tank to act as a spotter. The person entering the tank must be equipped with a harness, lifeline and respirator. Use only explosion-proof lighting (ie. flashlights) inside the tank.

E. For additional information, consult the following references:

1. FM 10-68, Aircraft Refueling.
2. AR 385-10, The Army Safety Program.
3. AR 385-55, Prevention of Motor Vehicle Accidents.
4. TB 43-0212, Purging, Cleaning and Coating Interior Ferrous and Terne Sheet Vehicle Fuel Tanks.
5. FM 10-71, Petroleum Tank Vehicle Operations.
6. OSHA Standard, 29 CFR 1910.146
7. TM 38-450, Storage and Maintenance of Preposition Materiel Configured to Unit Sets.
8. MIL-V-62038E(AT), Vehicles, Wheeled: Preparation for Shipment and Storage of.

F. Unit commanders, contact your local TACOM Logistics Assistance Representative (LAR) or your State Surface Maintenance Manager upon receipt of this message for assistance. If you do not know who your TACOM LAR is, for CONUS call DSN 367-6204/6293, for GERMANY DSN 370-6128/7436, and KOREA DSN 723-7519/6479. LARs are available to help you.

TACOM/PM ACTIONS:

A. Update applicable vehicle technical manuals.

B. Provide purging information to the field through EIR Digest article to be published in TB 43-0001-39-3. (3rd QTR CY 94)

SUPPLY STATUS:

Biodegradable purging solution is available in 6 gallon containers, NSN 7930-01-350-7034 and 55 gallon drums, NSN 7930-01-350-7035.

END OF MESSAGE

DISTRIBUTION LIST

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NEW JERSEY AIR NATIONAL GUARD
1 108TH ARW/LGQ (MSG MILLER)
33-22 FLEBELKORN ROAD
MCGUIRE AFB, NJ 08641-5406

CDR
FORT SAM HOUSTON
1 ATTN AFZG-DL-MO (MR ROGERS)
2107 17TH STREET
FORT SAM HOUSTON TX 78234-5036

CDR
ALASKA ARMY NATIONAL GUARD
1 ATTN AKNG-ARL-SMM (MAJ DEWAN)
P.O. BOX 5800
FORT RICHARDSON ALASKA 99505-5800

CDR
4TH SPECIAL OPERATIONS SUPPORT COMMAND
1 ATTN APSO (CPT SEABAUGH)
FORT SHAFTER HAWAII 96858-5435

CDR
THE SOUTH DAKOTA ARMY NATIONAL GUARD
1 ATTN SDCLO (LTC SLY)
2823 WEST MAIN STREET
RAPID CITY SOUTH DAKOTA 57702-8186

CDR
BRADLY AIR NATIONAL GUARD
1 103 CAM SQUADRON (MR FITZPATRICK)
100 NICHOLSON ROAD
EAST GRANBY CT 06026-5000

CDR
US ARMY MUNITIONS AND CHEMICAL
COMMAND
1 ATTN SMCRI-QAM-S (MR MAEHR)
ATTN SMCRI-DLD (MR CRAM)
ROCK ISLAND IL 61299-6000

CDR
KENTUCKY ARMY NATIONAL GUARD
1 ATTN KG-DOM (MR DUNAWAY)
100 MINUTEMAN PARKWAY
FRANKFORT KY 40601-6168

CDR
NEBRASKA ARMY NATIONAL GUARD
AVIATION SUPPORT FACILITY
1 BLDG 624 LMAP (CW3 MCKLEM)
LINCOLN NE 68524-1898

CDR
MISSISSIPI NATIONAL GUARD
MAINTENANCE SHOP
1 MATES BLDG 6800 (MR FARVE)
1 SHOP #1 (MAJ PYLANT)
CAMP SHELBY MS 39407-5500

CDR
10TH DIVISION SUPPORT COMMAND
1 HQ 10TH FORWARD SUPPORT BATTALION
(CPT MECCA)
1 HQ E CO 25TH AVIATION (SGT HEAD)
1 HQ B CO MSB (CW2 PHIPPS)
FORT DRUM NY 13602

CDR
HQ US ARMY ALASKA
FORT RICHARDSON (MR PENYAK)
1 600 Richardson Drive #5000
Fort Richardson Alaska 99505-5000

CDR
OREGON AIR NATIONAL GUARD
1 142 MAS (MR KOHL)
1 142 MAS ANG (MR SMITH)
1 142 MAS SQ/MAFAG (MR. KUTCHER)
1 142 MAS/MAWR (MR. BECKER)
6801 NE CORNFOOT AVE
PORTLAND OR 97218-2797

CDR
NEW HAMPSHIRE NATIONAL GUARD
1 US PROP & FISCAL OFFICE
PO BOX 2003
CONCORD NH 03202-2003

CDR
IOWA NATIONAL GUARD
1 EMC-C CAMP DODGE (MR SHROYER)
1 GS MAINTENANCE CO (MR DAVIS)
7700 NW BOAVER DR
JOHNSON IA 50131-1902

CDR
TRADOC
G4/DOL MAINTENANCE DIVISION
1 ATTN ATZK DLM
FORT KNOX KENTURCKY

CDR
TRADOC
DG/G5 MAITENANCE DIVISION
1 ATTN ATZK DLM (MR HAM)

FORT KNOX KENTUCKY

CDR
HQ US ARMY AVIATION & TROOP COMMAND
MAINTENANCE DIRECTORATE
1 ATTN AMSAT-1-MEP
4300 GOODFELLOW BLVD
ST LOUIS MO 63120-1798

CDR
CORPUS CHRISTI ARMY DEPOT
DIR COMP PDN, WAV/COMM DIV
1 CODE: 5WL5, STOP 90 (Mr. Torres)
CORPUS CHRISTI, TX 78419-5260

CDR
PENNSYLVANIA ARMY NATIONAL GUARD
1 AVIATION SUPPORT FACILITY
125 GOODRIDGE LANE
WASHINGTON PA 15301-0020

CDR
1 DELAWARE ARMY NATIONAL GUARD
ORGANIZATION MAINTENANCE SHOP #5
(MR BAKER)
RD 2 BOX 214C
DAGSBORO DELAWARE 19939-98021

CDR
WASHINTON ARMY NATIONAL GUARD
1 MILITARY DEPARTMENT (MR DOSLAND)
CAMP MURRAY
TACOMA WASHINGTON 98430-5000

CDR
FLEET ACTIVITIES CHINHAE
1 PSC 479 (MR HENDERSON)
FPO-AP 96269-1100

CDR
WISCONSIN ARMY NATIONAL GUARD
1 ATTN WIAR-F (MS NICHOLLS)
PO BOX 14587
MADISON WI 53714-0587

CDR
SOUTH DAKOTA AIR NATIONAL GUARD
1 114FG LGQ (MSGT KREULEN)
1201 W ALGONQUIN ST
PO BOX 5044
SIOUX FALLS SD 57117-5044

CDR
MASSACHUSETTS AIR NATIONAL GUARD
1 104TH FIGHTER GROUP (SMSGT SANVILLE)
BARNES MUNICIPAL AIRPORT
WESTFIELD MA 01085-1385

CDR
ARIZONA ARMY NATIONAL GUARD
1 FACILITIES MANAGEMENT OFFICE (CPT GILMAN)
5636 EAST MCDOWELL ROAD
BUILDING 331
PHOENIX AZ 85008-3495

CDR
ARKANSAS AIR NATIONAL GUARD
1 189 AG/MAFA (MR WILLIAMS)
4600 VANDENBERG BLVD
LITTLE ROCK AFB AR 72099-5065

CDR
MONTANA ARMY NATIONAL GUARD
1 DIRECT SUPPORT COBINED MAINTENANCE
SHOP (MR SMITH)
PO BOX 4789
HELENA MT 59604-4789

CDR
127TH F.W. SELFRIDGE ANGB
1 ATTN MR NOWICKI
MT CLEMENS MI 48045

CDR
U.S. Army Aberdeen Test Center
1 ATTN: STEAC-EV (Mr. Bill Newton)
400 Colleran Road
Aberdeen Proving Ground, MD 21005-5059

CDR
1 Army Atlanta Contracting Center
ATTN: AFLG-PRC (Ms. Williams)
Bldg 130
ANDERSON WAY, FT. MCPHERSON, GA
30330-6000

CDR
1 7th ARMY TRAINING COMMAND
AMC-FAST SCIENCE AND TECHNOLOGY
ADVISOR (Mr. Rees)
ATTN: AEAGX-SA, APO AE 09014

CDR
1 III CORPS
ATTN: AFZF-GL-T (Mr. Holley)
BLDG. 1001 ROOM C325
FT. HOOD, TX 76544-5056

CDR
1 1 CORPS & FORT LEWIS
ATTN: AFZH-DEQ, MS17C (Ms. Trout)
FT. LEWIS, WA 984-5000

DEPARTMENT OF THE NAVY:

CDR
NAVAL RSCH LABORATORY
1 ATTN CODE 6176 (R. MOWERY)
4555 OVERLOOK AVENUE, SW
WASHINGTON DC 20032

CDR
NAVAL SEA SYSTEMS CMD
1 ATTN SEA 03M3
2531 JEFFERSON DAVIS HWY
ARLINGTON VA 22242-5160

CDR
NAVAL SURFACE WARFARE CTR
CARDEROCK DIVISION
2 ATTN CODE 632 (MS Wenzel)
1 ATTN CODE 859
9500 MACARTHUR BLVD.
WEST BETHESDA, MD 20817-5700

CDR
NAVAL AVIATION DEPOT
MATERIAL ENGINEERING

2 CODE: 4.3.4.2 (Ms. Grant)
PSC Box 8021
CHERRY POINT, NC 28533-0021

CDR
NAVAL STATION MAYPORT
2 CODE: N4E9 (Mr. Tierney)
SCE ENVIRONMENTAL
P.O. BOX 280067
MAYPORT, FL 32228-0067

CDR
NSWCCD
1 CODE 631 (MR LUNDY)
US NAVAL BASE BLDG 619
PHILADELPHIA, PA 19112-5083

CDR
NAVAIR AIR
1 4.3.4JEM (MR MULLER)
1421 JEFFERSON DAVIS HIGHWAY
ARINGTON, VA 22243

CDR
Naval Aviation Depot North Island
Bldg 469, Materials Engineering Lab
1 Code: 434
San Diego, CA 92135-7058

CDR
NAVSEA
1 CODE: 07E21 (Mr. Adams)
2531 JEFFERSON DAVIS HIGHWAY
ARLINGTON, VA 22242

CDR
NAWC WARMINISTER
1 CODE: 4.3.4.1 (Mr. Bevilacqua)
WARMINSTER, PA 18974-0591

CDR
NAVAL AVIATION DEPOT, MCAS
1 CODE: 4.3.4.2 (Mr. Cahoon)
BLDG. 4032
CHERRY POINT, NC 28533

CDR
NAVY ENVIRONMENTAL HEALTH CENTER
1 2510 WALMER AVE (Mr. Drewyer)
NORFOLK, VA 23513-2617

CDR
NAVAL WARFARE SYSTEMS COMMAND
1 CODE: 10-11E (Mr. Gentilcore)
2451 CRYSTAL DRIVE
ARLINGTON, VA 22245-5200

CDR
COMNAVSURFLANT
1 Code: N411D
1450 MITSCHER AVE.
NORFOLK, VA 23551-2494

CDR
NSWCCD
1 Code 1413 (Mr. Kollar)
PHILADELPHIA Naval BASE
PHILADELPHIA, PA 19112

CDR
NAVSEA
1 CODE: 00T4 (Dr. McCray)
2531 JEFFERSON DAVIS HIGHWAY
ARLINGTON, VA 22242

CDR
NAVAIR
1 CODE: 3.6.1.2 (Mr. Quist)
1421 JEFFERSON DAVIS HIGHWAY
ARLINGTON, VA 22243

CDR
NADEP JACKSONVILLE
1 CODE: 343 (Rossi)
NAS
JACKSONVILLE, FL 32212-0016

CDR
NSWCCD
1 CODE 631 (Ruparelia)
BLDG. 619
PHILADELPHIA, PA 19112-5083

CDR
NAVY SPCC
1 CODE: 0541.5 (Mr. Sieger)
5450 CARLISLE PIKE
MECHANICSBURG, PA 17055-0788

CDR
NAVAL SEA SYSTEMS COMMAND
1 CODE: sea 00TB
2531 JEFFERSON DAVIS HWY.
ARLINGTON, VA 22242-5160

DEPARTMENT OF THE NAVY/U.S MARINE CORPS:

1 PROG MGR COMBAT SER SPT
MARINE CORPS SYS CMD
2033 BARNETT AVE STE 315
QUANTICO VA 22134-5080

CDR
MARINE CORPS LOGISTICS BA
1 ATTN CODE 837
1 ATTN CODE 883
814 RADFORD BLVD
ALBANY GA 31704

CDR
BLOUNT ISLAND CMD
1 ATTN CODE 922/1
JACKSONVILLE FL 32226-3404

CDR
MARINE CORPS LOGISTICS BA
1 ATTN CODE B880 (MR MSRTEL)
BARSTOW CA 92311-5015

DEPARTMENT OF AIR FORCE:

AIR FORCE WRIGHT LAB
1 ATTN WL/POSL
1790 LOOP RD N
WRIGHT PATTERSON AFB

OH 45433-7103

AIR FORCE WRIGHT LAB
1 ATTN WL/MLBT
2941 P ST STE 1
WRIGHT PATTERSON AFB
OH 45433-7718

AIR FORCE WRIGHT LAB
1 ATTN WL/MLSE
2179 12TH ST STE 1
WRIGHT PATTERSON AFB
OH 45433-7718

1 WR ALC/LVRS
225 OCMULGEE CT
ROBINS AFB
GA 31098-1647

DEPARTMENT OF DEFENSE:

DEFENSE SUPPLY Center Richmond
1 ATTN DSCR SSA
1 ATTN DSCR STA
8000 JEFFERSON DAVIS HWY
RICHMOND VA 23297-5000

1 DEFENSE TECH INFO CTR
8725 JOHN J. KINGMAN RD.
SUITE 0944
FORT BELVOIR VA 22060-6210